# THE WEATHER AND CIRCULATION OF DECEMBER 1964

## Record-Breaking Floods in the Northwest

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## 1. HIGHLIGHTS

The floods of northern California and Oregon in the latter half of December were the most important weather-related phenomena during the month in the United States. Very heavy rain that fell from the 19th to the 23d caused unprecedented flood waters in scores of river communities from northern California coastal drainage areas through western Oregon. Earlier storms had set up antecedent soil and surface conditions that contributed to the flood situation, and later heavy rains delayed the return of the rivers to normal. Many high water records established during the Christmas week of 1955 were exceeded, in some instances by as much as 10 ft. or more. Thousands of persons were driven from their homes by the flood waters. Numerous communities were isolated as highways and bridges were closed or washed out. Some communities, such as Klamath Glen, Calif., were totally destroyed. At least 40 persons lost their lives as a direct or indirect result of the floods [1].

Scattered and locally severe flooding also occurred in Idaho, Washington, and Nevada. The Sacramento River in California rose to significant levels, but flood control projects of recent years kept this river in the bankful stage at Sacramento. Scattered flooding also occurred as far south as the San Joaquin Basin in California.

Another major weather feature of December was a blizzard that crossed the Northern Plains during the 15th and 16th and caused heavy losses in cattle and sheep. This storm also contributed to the flood situation of the west coast, for it precipitated heavy snows over the western mountains. Later much of the snow in the Coastal and Cascade Ranges melted during the heavy rains.

## 2. MEAN CIRCULATION

The mean 700-mb. circulation for December (fig. 1) represents a decrease of the mid-latitude westerlies over the Western Hemisphere from the previous month. The average wind speed at these latitudes was 8.9 m./sec. compared to 9.8 m./sec. in November. This decrease was first manifested in a slow-down of the progression described by Dickson [2] in his discussion of the November circulation, and then after the middle of December retrogression occurred. Strong blocking ridges became entrenched over both the Atlantic and Pacific Oceans (figs. 1 and 2). Blocking was also present during the month over central Asia but was not nearly as pronounced as over the two oceans. The Pacific block had been present during November but became much more intense in December. Both the negative 700-mb. height anomaly to the south and the positive anomaly over the Aleutians increased considerably in magnitude. The Atlantic block was not present early in the month while the progression mentioned earlier continued; however, soon after the middle of December blocking became quite evident in the eastern Atlantic and moved steadily westward as it intensified during the last half of the month. The short wavelengths of the Western Hemisphere circulation during December are typical of blocking patterns. Over North America the main trough was in the central part of the continent, but a second trough was located just off the west coast.

Figure 3 illustrates how markedly the westerlies split around the two oceanic blocks. Over North America in between the strong blocks, where upper-level westerlies are normally split in December, the separation of the two branches was less than usual. The flow over nearly all of North America was quite zonal with much less amplitude than normal, which was in sharp contrast with the flow over the adjacent oceans.

## 3. TEMPERATURE

Frequent incursions of warm moist air from the Gulf of Mexico to the east of the main trough (fig. 1) resulted in above normal temperature in most of the eastern United States (fig. 4). At the same time, stronger than normal westerlies brought mild Pacific air into the West from Oregon and Idaho southward which resulted in above or near normal temperature for California, the high Plateau, the southern Rockies, and much of Texas.

The extremely low average temperature in the Northern Plains reflected the flux of cold continental air into the areas east of the mean ridge along the Rocky Mountains. Many areas in Montana, including Billings, Great Falls, and Havre, reported the coldest December of record. The source region for this continental air, Alaska and the Yukon Territory, was unusually cold during the month. Temperatures at Fairbanks, Alaska averaged 19° F. below normal (fig. 4) and at Dawson in the Yukon 24° F. below normal [3]. The very strong and persistent upper-level ridge over Bering Strait contributed to the cold of Alaska and the Yukon by favoring surface anticyclones which in turn favored clear skies and strong radiational cooling during the long nights.

## 4. PRECIPITATION

### FLOODS IN THE NORTHWEST

The extremely heavy rainfall over much of the Far West during December was associated with the strong

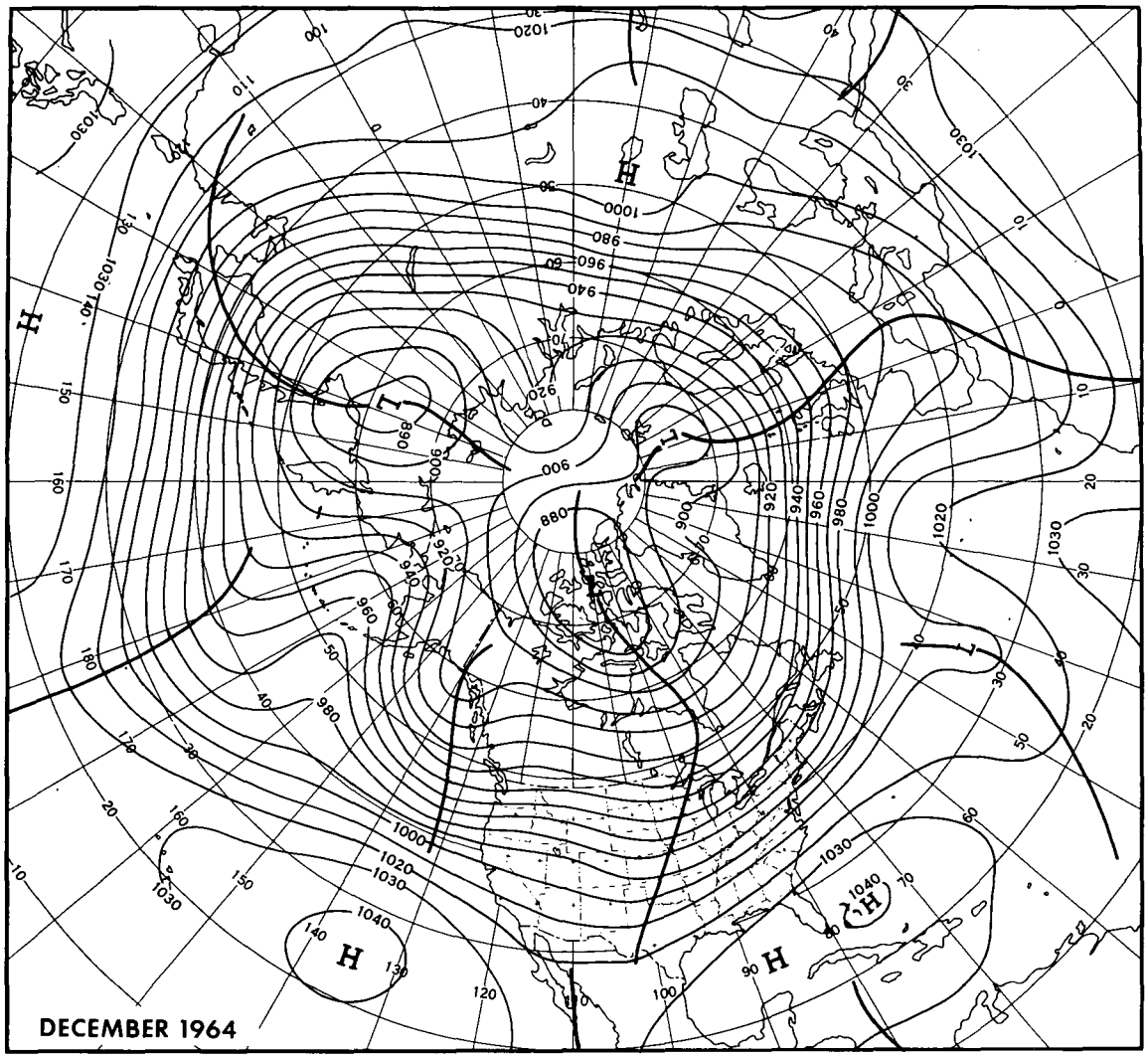


FIGURE 1.—Mean 700-mb. contours (tens of ft.) drawn at intervals of 100 ft. for December 1964.

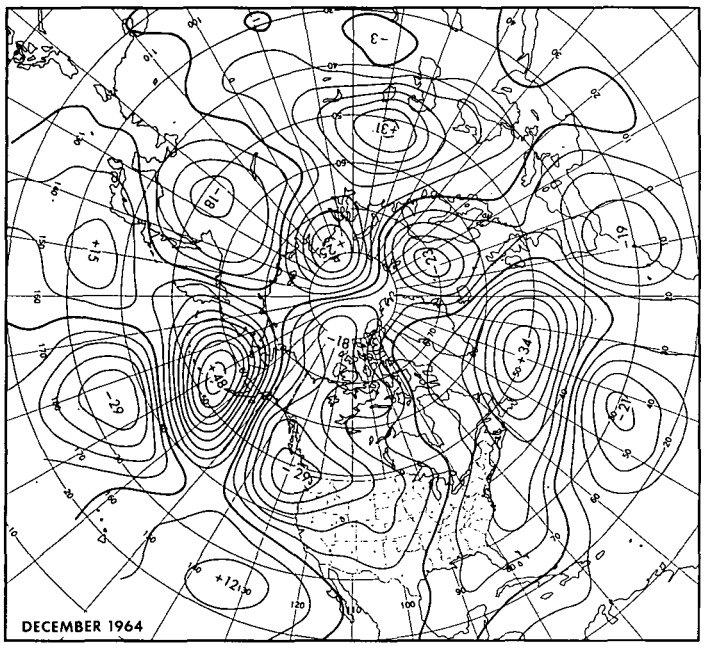


FIGURE 2.—Mean 700-mb. height departures from normal for December 1964, at intervals of 50 ft. with centers labeled in tens of feet and the zero isopleth heavy. A strong blocking pattern prevailed over the Atlantic and Pacific.

southwesterly flow and trough off the coast (figs. 1 and 2). More than 300 percent of normal precipitation (fig. 5) fell over large areas that usually have considerable amounts of precipitation during December. Most of this very heavy rain fell during a 5-day period and caused disastrous floods.

The large-scale synoptic situation over the eastern Pacific that brought the flood conditions was analogous to the regime that led to the record-breaking floods of December 1955 [4] in northern California and Oregon and to several earlier major flood situations in the same region. Most of these past flood situations in northern California and nearby States have been characterized by a strong southwesterly flow aloft that brings very warm and moist air from the vicinity of Hawaii up over the western mountains. Reference to figure 6 will show that during the period of heaviest rain this December (19–23) the main jet flow approached from the southwest just north of Hawaii in a similar manner. The only difference was one of intensity. Not only was the jet stream very strong when averaged for the 5-day period, but also the wind

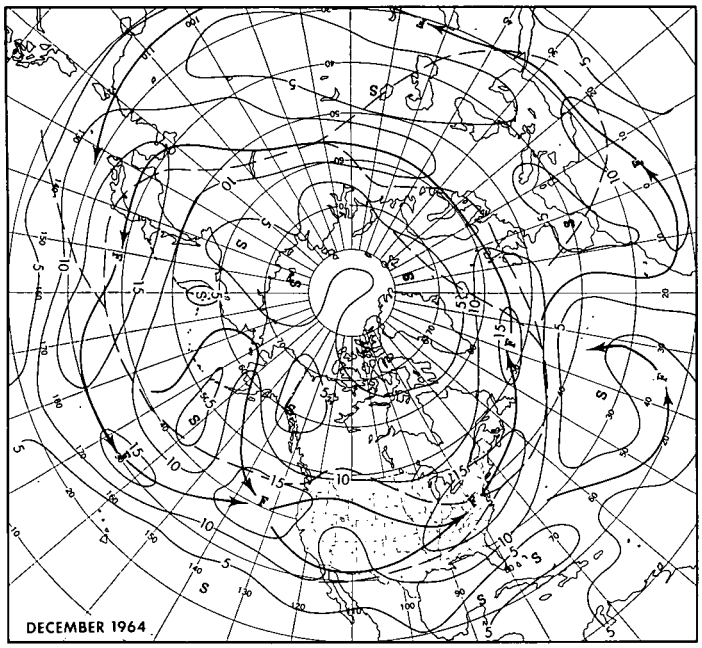


FIGURE 3.—Mean isotachs at 700 mb. (in. m./sec.) for December 1964. Solid arrows indicate the observed axes of maximum winds and dashed lines indicate the normal axes.

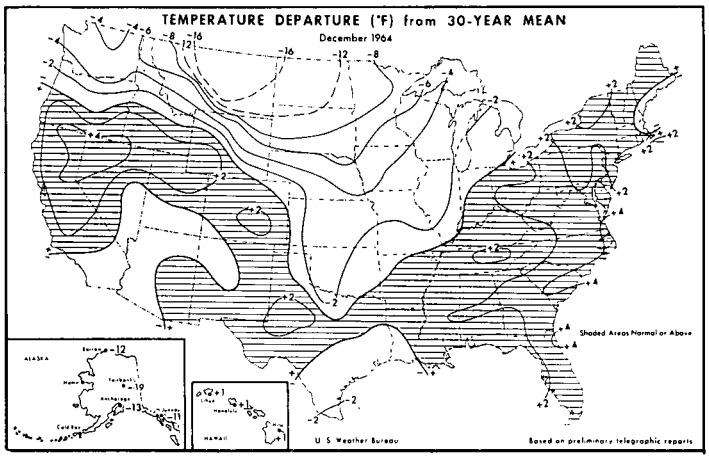


FIGURE 4.—Departure of the average surface temperature from normal (° F.) for December 1964 (from [1]). Record-breaking low temperatures were observed in the Northern Plains.

speeds were very persistent from day to day. At 40° N., 140° W. the 300-mb. wind speed averaged 134 kt. during the 5 days, and at no time was the speed less than 110 kt. at this point according to the objective wind analysis of the National Meteorological Center.

Heavy rains that occur in association with strong jet maxima are well documented [5]. Added to the dynamic lifting associated with the jet stream was the much stronger lift supplied by the winds approaching the western mountains in an almost right-angle trajectory. The isohyets in figure 6 give the broad outline of the rainfall during the flood period. Some of the heavier amounts are shown in table 1. The crest of the floods was greatly increased by the rapid melting of snow in the mountains. At Government Camp, Oreg., snow that was 45 in. deep on the morning of the 21st was only 6 in. deep two days later.

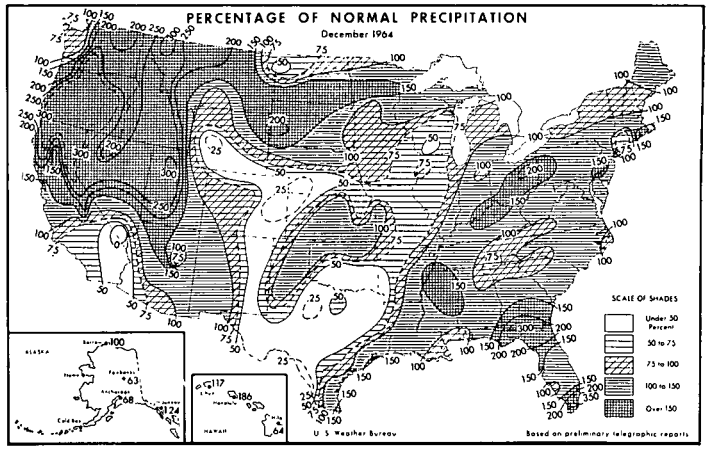


FIGURE 5.—Percentage of normal precipitation for December 1964 (from [1]). Very heavy precipitation fell over much of the West.

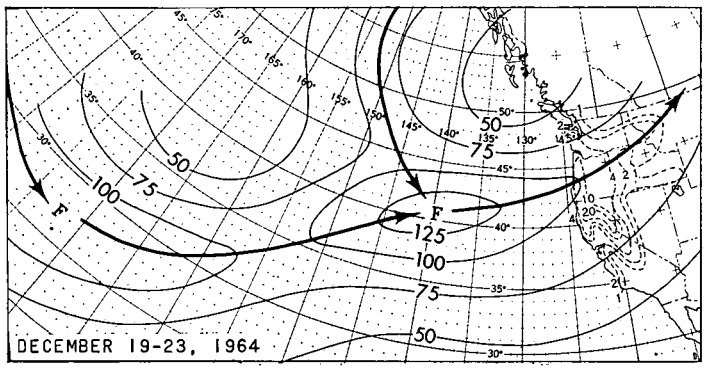


FIGURE 6.—Mean isotachs (kt., thin solid lines) over the eastern Pacific and isohyets (in., dashed lines) of precipitation in the Northwest for December 19–23, 1964. Heavy solid arrows are jet axes.

## PRECIPITATION ELSEWHERE

Southwesterly flow to the east of the mean trough through central United States resulted in above normal precipitation in most sections east of the Mississippi River (fig. 5), thus further alleviating the drought conditions of the previous summer and fall, following the improvement that occurred in November [2]. In Ohio, Dayton reported above normal precipitation for the first time in 8 months and Cleveland also recorded above normal precipitation following the driest November since 1924. Southern New England, southeastern New York, and parts of Pennsylvania received precipitation amounts in excess of 4 in. However, other areas in the Northeast,

TABLE 1.—*Precipitation amounts for selected stations in northern California for December 19–24, 1964*

| Station | Precipitation (in.) | Station | Precipitation (in.) |
|---|---|---|---|
| Blue Canyon | 29.3 | Garberville | 18.5 |
| Brush Creek | 24.4 | Whispering Pines | 18.4 |
| Camptonville | 22.5 | Hoopa | 12.9 |
| Shasta Dam | 21.9 | Deer Creek | 12.0 |
| Willits Howard Forest | 21.1 | | |

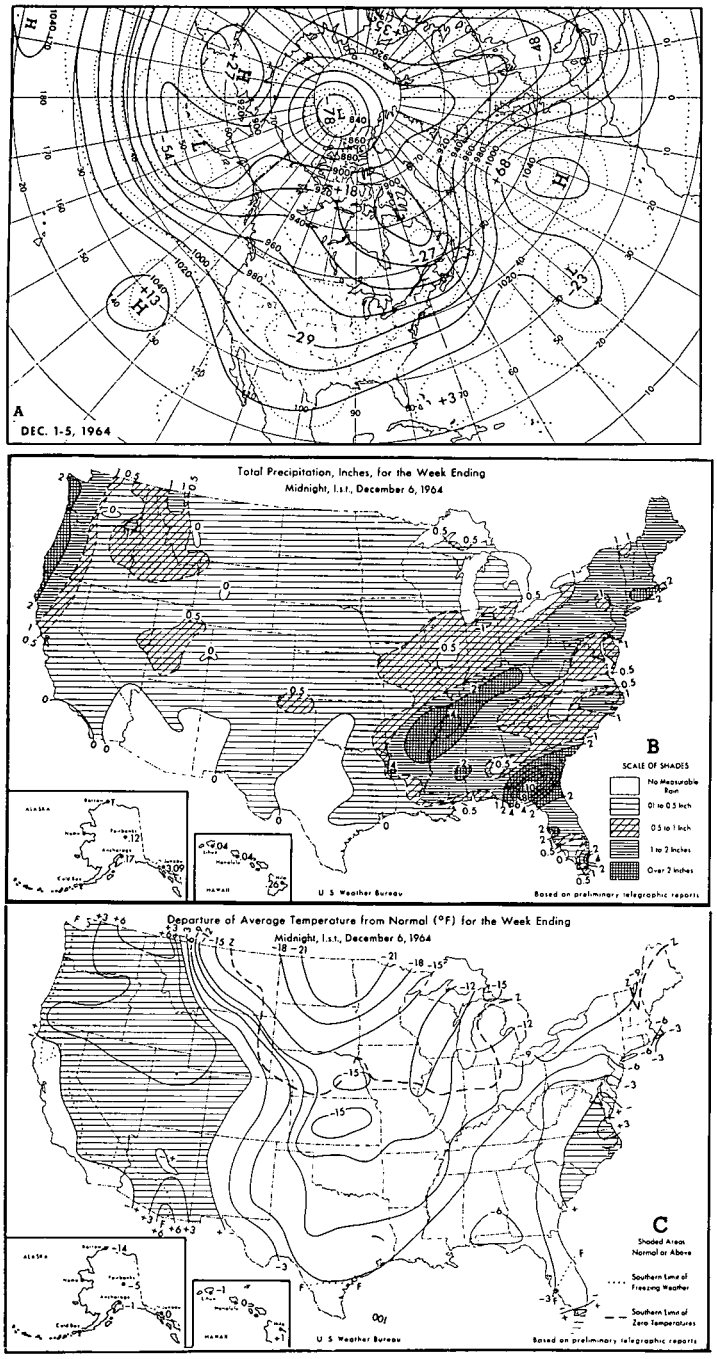


FIGURE 7.—(A) 700-mb. contours (solid) and height departure from normal (dotted) both in tens of feet, for December 1–5, 1964. (B) Total precipitation (in.). (C) Surface temperature departure from normal (° F.). (B) and (C) for week ending December 6, 1964 (from [1]).

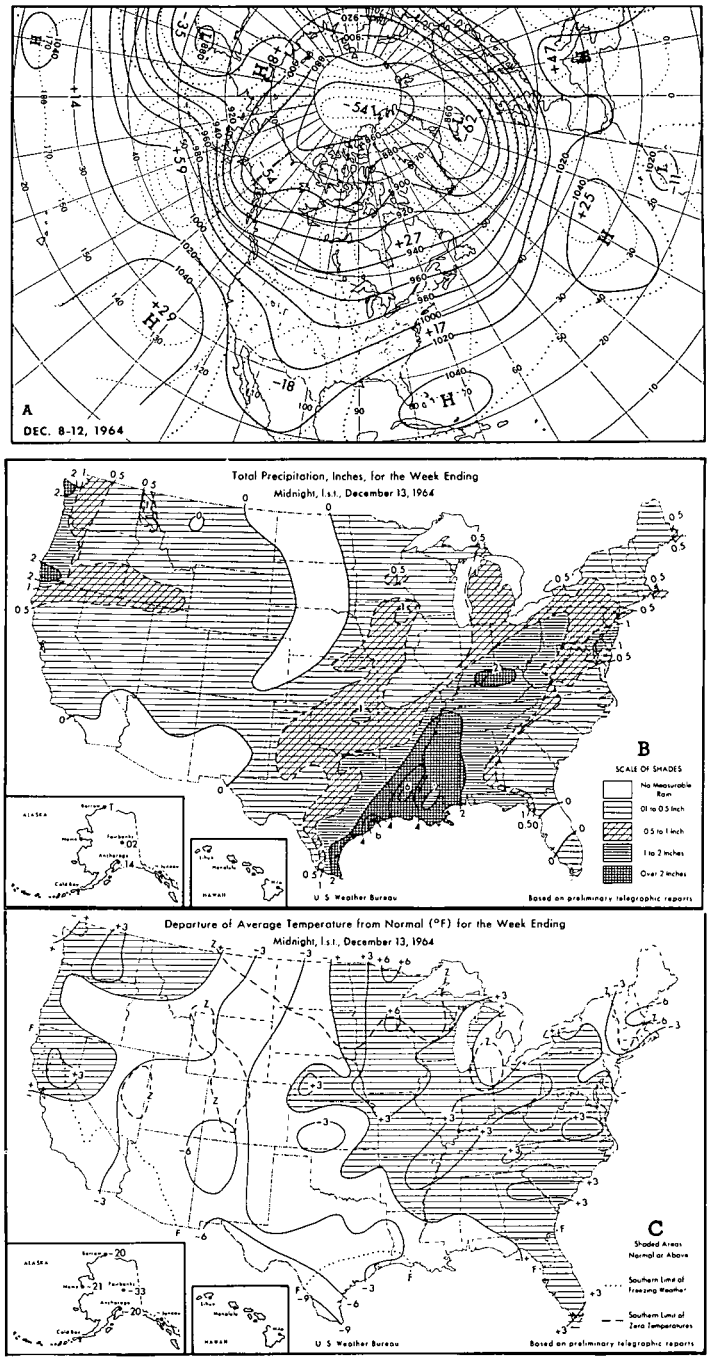


FIGURE 8.—(A) 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for December 8–12, 1964. (B) Total precipitation (in.). (C) Surface temperature departure from normal (° F.). (B) and (C) for week ending December 13, 1964 (from [1]).

while receiving some drought relief, still did not have normal rainfall for the month, and the long-time moisture deficiency became greater. Burlington, Vt. recorded 1.63 in. which was 0.50 in. below normal, and Williamsport, Pa. measured 2.66 in. (0.38 in. below normal). For Williamsport the deficiency for 1964 was 7.24 in. and nearly 17 in. for the past two years.

The shortage in annual moisture remained large in widespread areas of central and eastern United States. Madison, Wis., with only 0.34 in. during December, reported below normal precipitation during 8 months of 1964. Rochester, N.Y., ended the driest year since 1877 with a monthly deficiency of 0.34 in. El Paso, Tex., reported 0.52 in. for December, which was slightly above normal, but with seven unusually dry months during the year El Paso had only 5.35 in. during all of 1964. Cheyenne, Wyo. reported only 40 percent of normal precipitation during the year, which was the driest since 1900.

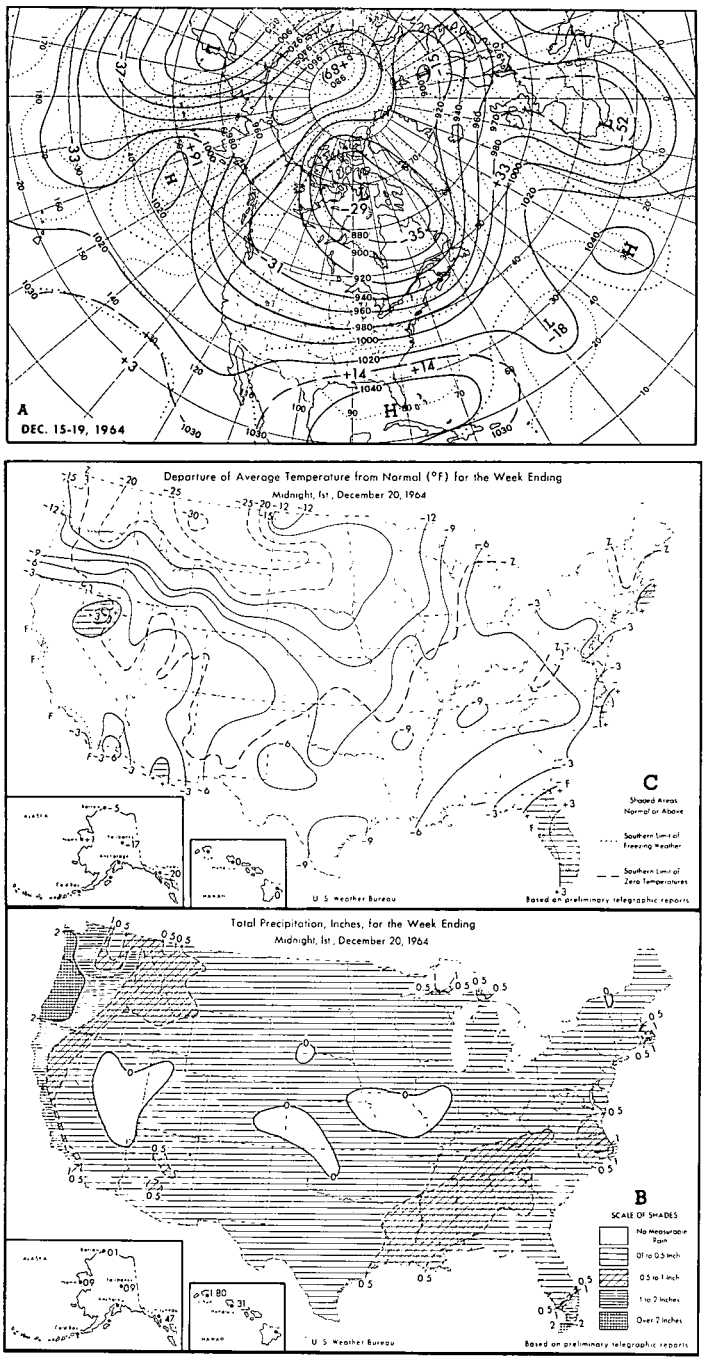


FIGURE 9.—(A) 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for December 15–19, 1964. (B) Total precipitation (in.). (C) Surface temperature departure from normal (° F.). (B) and (C) for week ending December 20, 1964 (from [1]).

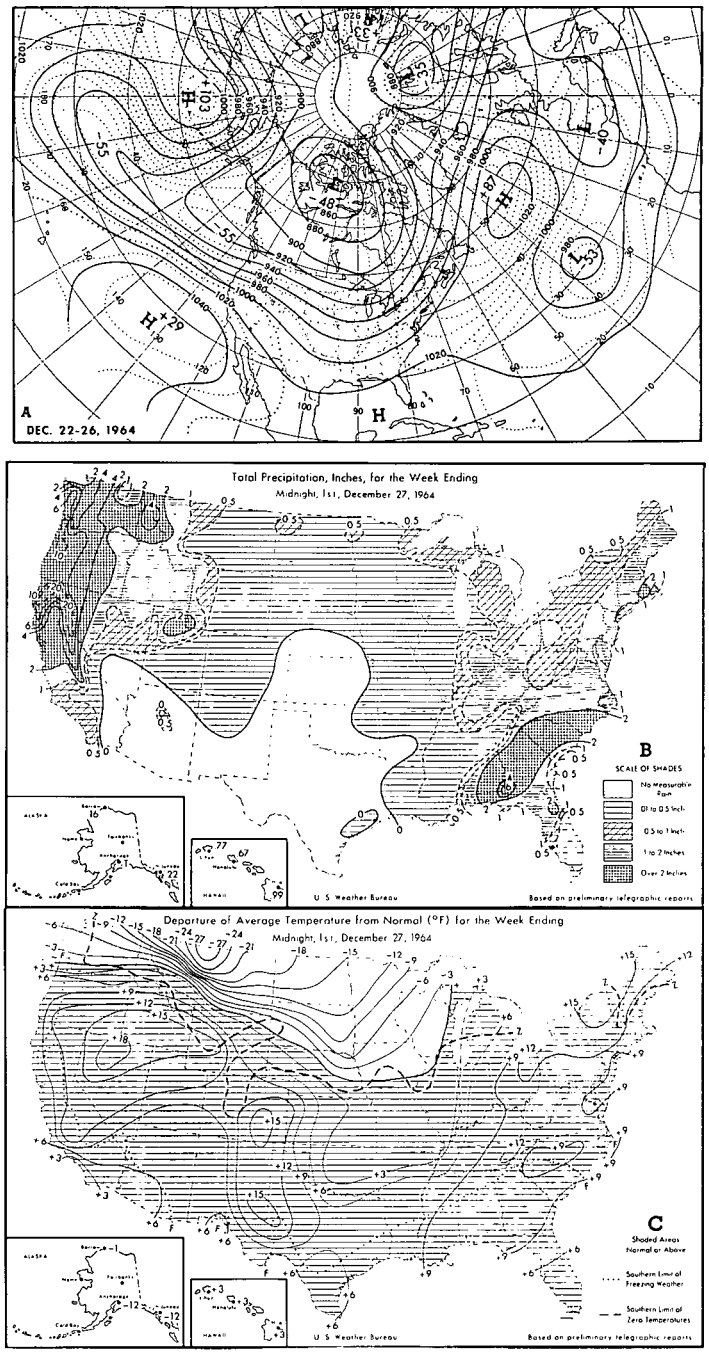


FIGURE 10.—(A) 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for December 22–26, 1964. (B) Total precipitation (in.). (C) Surface temperature departure from normal (° F.) (B) and (C) for week ending December 27, 1964 (from [1]).

Fort Myers, Fla., although reporting 32.83 in. for 1964, received the least annual rainfall since records began in 1891.

## 5. WEEKLY VARIATIONS

A mean upper-level trough (fig. 7A) advancing slowly through the eastern part of the country during the first week of December caused heavy rain in the lower Mississippi Valley and excessive rain in southern Georgia and northern Florida (fig. 7B). The central part of the Nation and the Southwest which were dominated by the mean ridge had generally light or no precipitation. Along the northwestern coast and the northern Rockies westerly winds carrying moist Pacific air resulted in fairly heavy rain for that section during the week. Most of the Nation east of the Rocky Mountains experienced a very cold week (fig. 7C), as the position and large amplitude of the mean ridge allowed cold continental air to penetrate to the Gulf of Mexico. Only a small area east of the Midwest trough had warm Gulf or Atlantic air present long enough to give above normal temperatures for the week.

West of the Rocky Mountains the westerly flow brought mild Pacific air and above normal temperatures.

As the progression of November [2] continued into the second week of December, the deep Low in eastern Canada and associated trough were replaced by a strong ridge (fig. 8A). However, the southernmost portion of the mean trough over Mexico and Texas did not progress but remained almost stationary. Then as the next major trough that moved eastward in the mid-latitude westerlies merged with this low-latitude trough very heavy rain started along the Texas coast and spread up the Mississippi and Ohio Valleys (fig. 8B). Although the ridge over the Rockies was much weaker than normal in the second week it did result in light or no precipitation over the Northern Plains and Rocky Mountains. Westerly winds continued to give appreciable rain or snow to the Northwest. In response to above normal 700-mb. height and anomalous southerly flow over the East, temperatures in most of the eastern half of the United States were above normal (fig. 8C). The western half of the country had generally below normal temperature associated with below normal 700-mb. heights.

Strong amplification of the broad-scale circulation occurred in the third week of December over North America and the adjacent oceans (fig. 9A). A very strong mean ridge developed over the eastern Pacific and northward across Alaska and over the Arctic Basin. Two centers of positive 700-mb. height anomaly were associated with the ridge, one over the Aleutians (910 ft.) and the other over the Arctic (890 ft.). The resulting downstream trough produced a blizzard across the Northern Plains that gave from 1 to 5 in. of snow from the Rocky Mountains to New England. Sleet and freezing rain fell along the southern boundary of the snow belt. This storm reached its greatest intensity just east of the Rocky Mountains (wind speeds reached 56 m.p.h. at Rapid City, S. Dak. and 57 m.p.h. at Cheyenne, Wyo.), then weakened as it moved eastward over the Great Lakes into southeastern Canada. Before reaching the blizzard stage this storm moved through the Northwest from the Pacific and gave heavy precipitation along the west coast (fig. 9B). Because of the distance from the Gulf of Mexico and the zonal character of the flow in southern United States during the passage of this storm, the total precipitation was relatively small over central and eastern United States. The heavier areas of precipitation in the Southeast occurred with trailing cold fronts. Following the blizzard a very large and extremely cold air mass spread southward from Alaska, in response to the ridge amplification, and covered all of the United States before the end of the week (fig. 9C). The lowest minimum temperature observed in December during the 31 years of record at the Billings, Mont., Airport was reported this week.

High-latitude retrogression during the fourth week caused the ridge connection from the southeastern Pacific to the upper-level High near the Aleutians to be broken. The resulting flux of vorticity around the large High centered over the western Aleutians in the fourth week of December carved out a deep trough in the central Pacific west of Hawaii (fig. 10A). The very long fetch of warm, moist, southwesterly winds to the east of this trough resulted in the flood-producing rainfall (fig. 10B) discussed in section 4. This current was very deep with almost parallel flow from the surface to the 300-mb. level (figs. 6 and 10A). Although the heaviest 7-day period of rain occurred during the week ending on the 27th, the heaviest 5-day rainfall fell from the 19th to 23d. A redistribution of vorticity downstream following the breaking of the ridge connection in the eastern Pacific led to a sharp trough development over the eastern United States. One of the storms which caused the floods of the Northwest swung southeastward through this trough as it deepened and produced the heavy rain shown in the Southeast (fig. 10B). The strong southwesterly current in the eastern Pacific also resulted in rapid and intense warming that spread over most of the West and the South Central States.

Temperatures were 15° to 18° F. above normal for the week over large areas of the high Plateau and the southern Rockies (fig. 10C). In the meantime, retrogression of the Atlantic block coupled with the sharp trough over the East gave a very strong southerly anomalous flow (fig. 10A) that warmed the East rapidly also. Temperatures ranged from 6° to 15° F. above normal over much of the country east of the Mississippi River, and many daily maximum temperature records were set in the East. The strong ridge over the Aleutians and Alaska combined with northwesterly flow in western Canada continued the very cold regime in the Northern Plains. Some of this cold air moved across the mountains into the State of Washington which was north of the main storm track, and most of Washington had below normal temperatures.

Retrogression continued during the last few days of December with the positive anomaly over the Atlantic centered near Newfoundland by the end of the month. This brought continued warmth to the East, but the west coast had begun to cool again under the influence of a deep trough near the coast. Heavy precipitation continued in the East and Far West the last few days of December.

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U.S. GOVERNMENT PRINTING OFFICE: 1965